Hybrid wheel loader

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a ‘hybrid’ cooperation

Volvo

Innas
maximum traction  240 kN
maximum speed  45 km/h
engine power  274 kW
fuel tank  335 l
OIL 335 l

≈ 0.1 kWh

≈ 1 kWh

3000 kWh
Hybrid?
Hydraulic + Hybrid = Hydrid
simulation study
starting points

- 30 metric tonnes wheel loader
- short loading cycle (Y-cycle)
Hybrid wheel loader

same engine
same performance

<50% fuel consumption
Hybrid wheel loader

decoupling the engine

hydraulic accumulators

efficient ‘floating cup’ pumps & motors

hydraulic transformers
new hydraulic circuit
hydraulic circuit

common pressure rail (CPR)
hydraulic circuit

“power plant”

= 

engine + pump
hydraulic circuit

- lift cylinders
- hydraulic transformer
hydraulic circuit

tilt cylinder
hydraulic circuit

steering cylinders
hydraulic circuit

auxiliaries

drive
new technologies
two new technologies

floating cup principle

hydraulic transformer
floating cup

- compact
- low torque ripple
- high starting torque
- low noise
- low cost
- efficient
floating cup principle
transformers

mechanical  electrical  hydraulic

\[(T \cdot \omega)_\text{in} = (T \cdot \omega)_\text{out}\] \[(V \cdot I)_\text{in} = (V \cdot I)_\text{out}\] \[(p \cdot Q)_\text{in} = (p \cdot Q)_\text{out}\]
Hydraulic transformation

\[ p_A \cdot Q_A = \text{constant} \]

\[ Q_T = Q_B - Q_A \]
Hydraulic transformation

- efficient
Hydraulic transformation

- efficient
- recuperative

\[ (p_A, Q_A) \]

\[ (p_B, Q_B) \]

flow \( Q \)

pressure \( p \)
Hydraulic transformation

- efficient
- recuperative
- amplification

\[ (p_A, Q_A) \rightarrow (p_B, Q_B) \]
Hydraulic transformation

- efficient
- recuperative
- amplification
- dynamic
Hydraulic transformation

❖ efficient
❖ recuperative
❖ amplification
❖ dynamic
❖ 4-quadrants
Hydraulic transformation

- efficient
- recuperative
- amplification
- dynamic
- 4-quadrants
- wide operating range
new technologies

- hydraulic transformers
- floating cup pump/motor
50% fuel consumption?
most important reasons

- high component efficiency
- energy recuperation
- avoiding throttle losses
- eliminating the torque converter
propulsion (excl. engine)

conventional

Hybrid

64% reduction of losses
cylinders (excl. engine)

88% reduction of losses
engine efficiency

conventional

- Torque [Nm]
- Speed [rpm]
- Efficiency levels: 15%, 20%, 30%, 35%, 38%, 40%
- 195 kW
engine efficiency

speed [rpm]

0 500 1000 1500 2000 2500

torque [Nm]

0 500 1000 1500 2000

15% 20% 30% 35% 38% 40%

Hybrid

101 kW
engine efficiency

about equal average efficiency

speed [rpm]

torque [Nm]

195 kW

101 kW

38%

35%

30%

20%

15%

40%
Results
Results

Y-cycle only!